Title 14—AERONAUTICS AND SPACE

Chapter I—Federal Aviation Agency

[Docket Nos. 6810, 7046; Amdt. No. 37-9]

PART 37—TECHNICAL STANDARD ORDER AUTHORIZATIONS

Crewmember Demand Oxygen Masks, TSO-C78; Oxygen Regulators, Demand, TSO-C89

The purpose of this amendment is to add new Technical Standard Orders (TSO's) for crewmember demand oxygen masks and demand oxygen regulators to Part 37 of the Federal Aviation Regulations. These TSO's contain the minimum performance standards that such masks and regulators must meet in order for manufacturers to identify them with the applicable TSO markings.

The standards for crewmember demand oxygen masks were published as a notice of proposed rule making (30 F.R. 9547, July 30, 1965) and circulated as Notice 65-18 dated July 26, 1965. The standards for demand oxygen regulators were published as a notice of proposed rule making (30 F.R. 15294, Dec. 10, 1965) and circulated as Notice 65-36 dated December 3, 1965. Because of the similarities and technically related aspects of the two standards, they are being simultaneously promulgated in this amendment to Part 37.

Numerous comments were received in response to Notices 65-18 and 65-36. The more pertinent of these comments, together with the changes in the proposals resulting therefrom are discussed in detail hereinafter.

The parenthetical reference "air carrier or transport category aircraft" and the phrase "to be used on air carrier or transport category civil aircraft" have been deleted from the section catchlines, the titles of the Standards, and the applicability statements of the final regulations. Such statements have created some confusion and they serve no useful purpose insofar as the TSO's are concerned. A TSO contains those standards a manufacturer must meet in order to identify his equipment with the applicable TSO marking. A manufacturer desiring to use the applicable TSO marking must meet the prescribed Standard regardless of the type of operation or the type of aircraft in which the equipment might be used. Thus, the performance standards set forth in the TSO's are mandatory only for equipment manufactures who wish to obtain TSO authorization covering their equipment and are not directed to persons who install or use such equipment in aircraft.

Crewmember demand oxygen masks. Concerning the status of presently approved and installed masks after the effective date of the TSO, two commentators recommended inclusion of a state-

(As published in the Federal Register [32 F.R. 125]7 on January 7, 1967)

ment that presently approved masks can continue to be manufactured and installed and that the TSO relates only to new design masks. As previously stated, this TSO contains minimum performance standards that oxygen masks must meet in order for the manufacturer to identify it with the applicable TSO mark. The TSO is not directed to persons who install or use this equipment in aircraft. From an operational standpoint, the Technical Standard Order system merely provides one means by which equipment is approved. Unless the operating rules require equipment to be TSO approved, an operator may use any approved equipment. From the standpoint of the identification of a piece of equipment as being TSO approved, the applicability statement of the TSO clearly states that it is only "new models" of oxygen masks that must meet the new Standard in order to be identified as being manufactured under a TSO authorization. However, consistent with other TSO's the Agency considers it appropriate to include a provision specifically indicating that presently approved masks may continue to be manufactured under the provisions of the original approval.

One of the preceding commentators also suggested specifying the extent to which a TSO-approved mask can be modified before it is considered a new model requiring TSO requalification and the extent to which a non-TSO mask can be modified before it must be qualified under the TSO. The Agency does not believe the proposal need be changed in this regard since design changes in articles manufactured under a TSO authorization are objectively covered in § 37.11 of Subpart A of Part 37, and design changes to non-TSO items are outside the scope of Part 37.

Paragraph 2.2 of the TSO allows protective goggles to be included as part of the mask. One recommendation would add vision restriction limits for full face (smoke protection) masks and another would require marks not incorporating integral goggles to be designed for use with standard full-eye protection goggles. While the intent of the TSO is to permit the oxygen mask to serve as a smoke mask where eye protection is provided, the detailed standards relate only to oxygen masks. The recommendations, therefore, are beyond the scope of the TSO and must be rejected.

One manufacturer recommended that paragraph 2.4 quantitatively define the amount of expiratory gases permitted to accumulate within the facepiece chamber. The actual facepiece chamber volume that constitutes a hazard in any given mask, however, depends on a number of interrelated factors i.e., maximum approved altitude, inlet valve design, etc. Since these variables make regulatory quantification impracticable, the proposal has not been changed as suggested.

Four commentators took exception to proposed paragraph 2.5 which would have required that expiratory gases not impinge on the inhalation port or valve. They pointed out that in many present masks the inhalation valves receive impingement of expiratory gases which in the case of coaxial valves, actually assists in opening the exhalation port. Since inhalation valves are not subject to the collection of moisture and frost, as are exhalation valves, the Agency agrees that the requirement is unnecessary and proposed section 2.5 has been deleted.

Proposed paragraph 2.6 stated the basic requirement that mask design must prevent frost interference with exhalation valve functioning. One commentator suggested deletion of the exception to the basic requirement that would allow frost removal from the exhalation valve by external manipulation if it can be shown that such removal can be accomplished without removing the mask. Since it is unlikely that frost buildup, even if encountered, would need frequent removal by external manipulation, the Agency believes that this exception is appropriate. Proposed paragraph 2.6 (now paragraph 2.5) is, therefore, adopted without change.

Comments on proposed paragraph 2.8 noted that the hose disconnect warning device requirement appears to be more a system specification than a mask specification and recommended a higher flow restriction percentage to provide a better warning. Actually, the restriction device will be installed in the mask supply line and, therefore, is a part of the mask assembly. The 25 percent maximum restriction value was determined by the Civil Aeromedical Research Institute, Oklahoma City, which considered, inter alia, that too high a restriction introduces the danger of lung collapse. The paragraph (now 2.7) is being retained as proposed.

With reference to the quick-disconnect coupling set forth in paragraph 3.1, one commentator recommended a reduction in the minimum symmetrical separation force to 10 pounds following the military specification, while another commentator suggested that the stated force should be the minimum regardless of the direction of application. The Agency agrees that the minimum separation force may be set at 10 pounds but does not believe it necessary to specify minimum non-symmetrical separation forces since in those cases, a force applied along a non-symmetrical axis would probably be higher, not lower, than the symmetrical separation force. Paragraph 3.1 has been amended to reflect the 10-pound minimum force exerted along the axis of symmetry.

A number of comments were addressed to the leakage performance requirements of paragraph 3.3. As to a recommendation that the TSO specify outward leakage requirements for pressure demand masks, the Agency does not believe it necessary inasmuch as small outward leaks, while wasteful, do not impair proper operation of the mask and large leakage rates would be readily detectable and stopped by the wearer by adjusting the fit of the mask. Two recommendations to increase the 0.10 LPM STPD inward leakage rate must be rejected since this value already represents the highest portion of the maximum total system leakage allowable to the mask. Various recommendations that the negative differential pressure range over which the leakage rate is applicable be either increased or decreased were unsupported and the values as proposed are adopted.

One commentator recommended that paragraph 3.3 include a test requirement that the mask be sealed to the face or test plate and that the leak test include the hose-to-regulator connector. The intent of the requirement, however, is that the leakage rate specified for the given range of differential pressures be applicable to the mask as normally worn on the face (including the effects of mask fit to the face) or to the mask positioned on a suitable equivalent test stand and not to a mask sealed against peripheral leakage. Paragraph 3.3(a) has, therefore, been amended to make it clear that the leakage standard pertains to the mask as normally used. This change makes it unnecessary to include specific mention of the hose-to-regulator connector.

A number of comments recommended changes to the numerical values contained in the tables in paragraphs 3.4 (a) and (b) allegedly to reduce the fatiguing effect due to flow resistance. However, the agency's evaluation of these recommendations indicates that in some instances there is no fatiguing effect to be relieved while in others, a change would actually increase breathing resistance. At the maximum flow rate, fatigue is not a factor because of the short time duration involved. In still other cases, the suggested changes are equivalent in effect to the values given in the table. Therefore, the proposal has not been changed as suggested. However, the Agency does find merit in the suggestions that the oxygen supply tube referenced in paragraph 3.4(a) should include the oxygen supply connector and that, since expiratory gases do not flow through the supply tube, the reference to the oxygen supply tube in paragraph 3.4(b) should be deleted. Paragraphs 3.4 (a) and (b) are changed accordingly.

Proposed paragraph (c) of section 3.4 provides that the mask must not suffer damage at gas flows up to and including 120 LPM. Subsequent review of this proposal in light of comments received reveals that since 100 LPM is the maximum inhalation flow rate that would occur after substantial exercise, there is no need to test for damage at 120 LPM. Paragraph 3.4(c) has, therefore, been deleted.

In response to comments concerning the need to clarify the proposed paragraph 3.5, the Agency has rewritten the pressure-demand exhalation valve performance standard to remove any ambiguity concerning the facepiece pressure and supply tube pressure requirements for valve opening.

Pointing out that a mask in use will not be subjected to the frequency, acceleration, and amplitude enumerated in proposed paragraph 3.6(b), one commentator concluded that the vibration standard applies to the stowed condition

and recommended a change to require that the mask comply with paragraphs 3.3 through 3.5 after being subjected to the vibrations stated in paragraph 3.6(b). Upon further review, the Agency agrees that such a test does not represent a minimum requirement, and, noting that military specifications do not require vibration tests, has deleted the requirements proposed in paragraphs 3.6 (b) and (c).

The low temperature storage and test temperatures proposed in paragraphs 3.8 and 3.9 were stated to be unreasonably low by two persons who proposed higher temperatures. The Agency agrees that storage at −67° F. as required in paragraph 3.8 is unrealistic and the temperature has been raised to 0° F. Likewise, for the low temperature test delay set forth in paragraph 3.9, 20° F. in place of −40° F. is considered adequate to insure proper operation. Both the storage temperature in paragraph 3.9(a) and the test temperature in paragraph 3.9(b) are changed accordingly. A further suggestion that paragraph 3.9 be reworded to refer to "delay apparent to the user" rather than "apparent delay to the user" points up an ambiguity in that paragraph. Since the intent of the paragraph is to preclude any apparent delay, the words "to the user" are inappropriate and the paragraph has been revised accordingly.

Various comments were directed to the decompression requirements for masks not equipped with pressure relief valves as stated in proposed paragraph 3.10(a). One suggested that the high operating altitude of the supersonic transport might influence the depressurization pressure ranges. Another recommended inclusion of human "subjective" testing at the maximum approved altitude.

In connection with the foregoing, the maximum approved altitude criterion for masks is based on the maximum environmental (cabin) altitude rather than maximum aircraft operating altitude. Thus, for the supersonic transport where cabin altitudes in the event of decompression are expected to be no higher than 40,000 feet even though the airplane may be operating at 70,000 to 80,000 feet, the mask described in this proposal will be satisfactory. The Agency does not believe that it is necessary to specify human subjective testing at the maximum altitude although it does agree that the tests should properly simulate conditions of use. We have, accordingly, amended paragraph 3.10 to require decompression tests under conditions simulating those of the mask being worn by a crewmember.

The proposed 10-second decompression test time in paragraph 3.10(a) was geared to the large type airplanes. A related comment correctly points out that this time is unrealistic and unsafe for the small volume, high-performance airplanes which may undergo decompression in less than 2 seconds. One manufacturer stated that a 1-second, or even shorter, decompression time requirement would impose no additional design or manufacturing burden on mask suppliers. Therefore, to accommodate the wide variety of cabin volumes of high-altitude aircraft in which the mask may be used, the decompression test time requirement has been decreased from 10 seconds to 1 second.

Noting that values for pressure relief valve operation are not valid unless related to minimum regulator requirements that have not yet been established by the Agency, one commentator contended that the pressure relief valve schedule given in proposed paragraph 3.10(b) was too low. Assuming a regulator pressure on the order of 15 inches H_2O to be required at 45,000 feet, the spread between opening and maximum was declared to be too small as was the proposed maximum pressure on opening. The schedule was further considered unrealistic and impractical in that it required the pressure relief valve to regulate and to close at the same pressure, whereas the closing point must be slightly below the minimum regulating pressure.

In connection with the foregoing comments, the mask requirements have been made compatible with those of the regulators being promulgated simultaneously in this rule-making action. On this basis, the Agency agrees that the pressure schedule should be increased and paragraph 3.10(b) has been amended to require an opening pressure of 17" H_2O, maximum pressure within 5 minutes 18" H_2O, maximum differential pressure 20" H_2O and closing pressure 14" H_2O.

Interpreting the simulated breathing schedule of paragraph 3.11 as requiring a total of only 25,000 cycles, one commentator recommended a tenfold increase in the number of cycles. Insofar as this comment indicates an ambiguity in the number of cycles required, we concur with the need for change. However, we do not agree that 250,000 cycles are necessary. The intent of the requirement is to assure adequate reliability rather than to establish minimum service life. Since the proposed schedule is additive as to the number of required cycles, the paragraph is amended to make clear that the total is 50,000 cycles.

In response to another comment, the last sentence of paragraph 3.11 is amended to state a requirement for a constant time interval between respiratory cycles.

In addition to the requirement that the microphone not interfere with the mask, it was suggested that the requirements of paragraph 3.13 should state that the operation of the mask must not interfere with use of the microphone and that qualitative tests be included to assure compliance with both of these requirements. However, since mask-microphone compatibility is a system requirement rather than a mask performance requirement, the TSO is properly limited to performance requirements that will insure proper operation of the mask. Nor does the Agency believe that qualitative tests are necessary in this regard since compatibility will be checked during approval of the installation in an aircraft.

Several comments were directed to the quality control production tests, paragraph 4.1, which are simply an inward leakage test. One commentator thought the tests insufficient to establish that each mask assembly had been assembled correctly and suggested that more stringent production tests be required. In this connection, however, demonstration of the inward leakage rate of each mask is considered adequate for production tests since the quality control procedures of the manufacturer are examined as a part of the TSO approval process prescribed in §§ 37.5 and 37.15 of the FARs. Two other commentators noted that the leakage determination is not required to be made on masks for different sized and shaped faces. The purpose of the leakage production test is, among other things, to check whether the mask's flexible seal is capable of making a low-leakage connection with a surface having a face-like shape. It is not intended to insure a low-leakage fit on each prospective user of the mask, or even to insure a low-leakage fit on a variety of face shapes. A single face-like shape could conceivably be used to test a full production run.

Speaking to the quality control random tests, paragraph 4.2, one commentator recommended that lot sizes be at least 1,000 and that the requirement to comply with paragraphs 3.6(b), 3.6(c), 3.7, and 3.9(b) be deleted in view of the cost of the tests. The proposal, however, does not place a low limit on the lot size but rather leaves it to the selection of the applicant subject to approval of the Agency. Also, proposed paragraphs 3.6 (b) and (c) have been deleted as discussed before. To insure adequate testing of random samples, the Agency believes it necessary to retain the acceleration load test, paragraph 3.7 and the low temperature delay test at the low temperature, paragraph 3.9(b). Some of the objection to the latter may have been met by relaxation of the test temperature as previously discussed.

Comments received concerning proposed paragraph 5.0 contained various recommendations that the 40,000 feet maximum operating altitude for straight or diluter-demand masks be either increased or decreased. However, the use of straight and diluter-demand masks at altitudes up to 40,000 feet has been allowed under current airworthiness regulations for some years. On the basis of their service record, the Agency sees no need to reduce the maximum operating altitude. On the other hand, the Agency does not have enough data to justify increasing the maximum altitude for straight or diluter-demand masks as requested and the information submitted with the recommendation for such an increase does not contain the necessary justification. Therefore the provisions of paragraph 5.0 are adopted as proposed.

From the comments received concerning paragraph 5.0 it is apparent that the term "maximum operating altitude" as used in that paragraph has created some confusion since it may be interpreted as referring to aircraft operating altitude rather than the altitude of the environment in which the mask is being used (cabin altitude) as was intended. To make it clear that paragraph 5.0 of the

TSO is not an operating requirement, it has been amended by deleting the term "maximum operating altitude" and using instead the term "maximum environmental (cabin) altitude."

Oxygen regulators. In response to a recommendation for clarification, we have amended paragraphs 2(c), 2(d), 3.4, 3.5, 4.2(a), 4.2(b), 4.3(a), 4.5(a), and 4.6(b) to refer to pressure breathing regulators instead of pressure regulators as originally proposed.

Since, as one commentator correctly points out, oxygen regulators may be designed for shoulder, chest, or other type mounting, paragraph 3.1 has been amended to provide for mounting on a crewmembers clothing or safety harness in addition to mounting on a mask.

We agree with the suggestion that, for fire protection, regulators must have self-extinguishing characteristics, even though they may be constructed of plastic type materials. Paragraph 3.2 has, therefore, been amended by adding the requirement that regulators be at least flame resistant.

One commentator recommended that paragraph 3.3(a), applicable to all demand regulators, permit the filter to be placed at the oxygen inlet hose assembly as well as at the oxygen inlet port. The Agency agrees that this would allow the use of a larger and more reliable filter in the case of mask mounted regulators. The Agency also agrees with recommendations that the screen be not coarser than 200 mesh. Paragraph 3.3(a) has been amended to incorporate both recommendations.

Reading paragraph 3.3(b) as perpetuating a military requirement, one commentator recommended a change to permit only 100 mesh screen in place of the 30 to 100 as proposed but gave no reason why the coarser meshes were thought to be unsatisfactory. The 30 to 100 mesh range has been retained although the paragraph has been reworded to permit multiple screen filters.

One manufacturer advised that regulators may be designed to provide undiluted oxygen by means other than closing the air inlet diluter port, for example, by sensing a certain supply tube pressure. The Agency agrees with a recommendation to broaden the requirement and has amended paragraph 3.4 to state objectively the requirement without specifying the design detail by which this is to be achieved.

Various suggestions were made to change the positive pressure of 11.0±1.0 inches H_2O required by paragraph 3.5. At one end of the range it was recommended that a pressure of 3.5 inches H_2O be considered in order to give a safety pressure capability to the regulator in case of fumes or smoke in the cockpit. The Agency, however, does not agree with this recommendation since (1) protective breathing safety pressure is not needed if the mask fit is proper and, (2) protective breathing equipment, when provided, may utilize a separate regulator and the normal regulator might not be used during smoke or fume emergencies. While nothing in the Standard would preclude a manufacturer from including, as an added feature, a "safety pressure" feature, it should not be a minimum safety requirement. Other commentators, while agreeing with the 11-inch pressure base, recommended varying values in the permissible variation. The Agency agrees that the range of leakage check pressure can be extended and has accordingly amended the requirement to specify 11.0±3.0 inches H_2O.

One commentator recommended that mask-mounted regulators be excluded from the flow indicator requirement of paragraph 3.6 and further that "cylinder oxygen" for which a flow indicator is required be changed by deleting the word "cylinder." Another commentator expressed belief that flow indication is required only for dilution type regulators since a crewmember will know by the increased suction when a nondilution type regulator is not flowing oxygen. The Agency agrees with these recommendations and they have been incorporated into paragraph 3.6.

Several objections were made to the .92 inches of water outlet suction pressure required for the 100 LPM flow as stated in paragraph 4.1(a). Higher outlet pressures, as generally recommended, would make it easier to achieve the specified flows but would require a greater breathing effort on the part of the using crewmember. The Agency agrees with one commentator that the pressure for the 100 LPM flow may be increased to 1.0 inches of water since the increased breathing effort would occur for only short periods of time during heavy breathing. However, an increase to 1.5 inches of water at all flows, as suggested by another, would require added breathing effort for long periods even during light or moderate breathing rates.

The Agency rejects a recommendation that paragraph 4.2 specify dynamic testing rather than static (constant flow) testing since experience has shown that regulators which meet constant flow requirements have been satisfactory under varying flow conditions. Likewise the Agency does not agree with a suggestion that the diluter-demand pressure column be deleted from the table in paragraph 4.2(a) and that the diluter-demand column show the minimum for both diluter demand and diluter-demand pressure regulators inasmuch as the oxygen mixture requirements are different for the two types.

A number of comments addressed the numerical table proposed in paragraph 4.2(a). One recommendation would have stopped altitude listing at 35,000 on the ground that there is no dilution above that altitude and dilution tables are not normally shown above 35,000. However, as presented, the table indicates the 40,000 feet environmental altitude limit of the diluter demand and the 45,000 feet limit of the diluter-demand pressure regulators and will therefore be retained. In this connection, the Agency does agree the table presented an ambiguity in showing a zero value as the percentage of cylinder oxygen for diluter demand at 45,000 feet when, in fact, the percentage of cylinder oxygen is not applicable at that altitude.

The Agency must reject a suggestion that the 91 percent shown in the paragraph 4.2(a) table for 35,000 be raised to 96 percent. While such a change would be consistent with existing military specifications, 91 percent provides the minimum tracheal oxygen partial pressure required for physiological reasons. A manufacturer, of course, may provide in excess of 91 percent if he so elects. However, we do agree with another recommendation that all values of 96 percent minimum percent oxygen in paragraphs 4.2 (a) and (b) be increased to 98 percent. This will provide a 2-percent allowance for system deficiencies such as mask leakage where the applicable airworthiness standards (i.e., FAR § 25.1443 (b)) require 95 percent oxygen by volume for each crewmember at cabin pressure altitudes above 35,000 feet.

As two commentators pointed out, flow rates at altitudes other than sea level, to be meaningful, must be stated for conditions of ambient temperature and pressure. Therefore, paragraphs 4.2(a), 4.3, 4.4, 4.5 and 4.9 are amended to show ATPD in place of STPD.

Many comments were submitted with reference to the paragraph 4.2(a) table. The Agency does not agree that a minimum positive outlet pressure of 2.5 inches of water is required at 40,000 feet, since an adequate level of oxygen saturation will be maintained in the blood when breathing nonpressurized oxygen at that altitude. For the same reason we do not believe that any positive safety pressure need be maintained at altitudes between 30,000 and 40,000 feet to prevent mask inboard leakage. Moreover, the Agency does not agree with other recommendations that the minimum allowable positive outlet pressure be increased since the values proposed will provide adequate oxygen in the bloodstream. However, we agree that pressure tolerances may be widened at all specified altitudes and the table has been amended accordingly.

The Agency does not agree that the basic 20 LPM flow rate specified in paragraphs 4.3(a), 4.3(b), and 4.3(c) should be reduced inasmuch as this value represents a normal breathing rate. Similarly, a recommendation that the range of flow rates in paragraph 4.3(c) be changed to 0.16–10 LPM was not supported by any justification.

Pointing out that there are other acceptable methods of measuring leakage rate, two commentators recommended deletion of the last sentence of paragraph 4.4(d) that proposed to determine leakage on the basis of a decrease in pressure during a 2-minute period. The Agency agrees and has deleted the sentence. Also the ambiguous phrase "oxygen supply port" as proposed in paragraphs 4.4 (c) and (d) has been clarified to read "regulator outlet port."

In the proposed paragraphs 4.5 (a) and (b), we agree that the negative pressure stated in terms of inches of mercury should be stated in inches of water. Also, for the tests specified in the same paragraphs, it is necessary to clarify that the regulator inlet port, as well as the diluter valve, be closed. Paragraphs 4.5

(a) and (b) have been amended to incorporate these changes.

As discussed previously in this preamble in connection with TSO-C78, *Crewmember demand oxygen masks*, an allowance of 10 seconds is not representative of the decompression interval that can occur in small volume aircraft having high altitude capabilities. Following a recommendation for a shorter decompression time allowance, the Agency has determined, from the information available, that imposition of a one-second decompression requirement will impose no added design or manufacturing burden on the producers of regulators. In the interest of safety, paragraphs 4.8 (a) and (b) are amended to place a one-second decompression capability on all regulators.

The Agency agrees with one comment that performance compliance at 160° F. in Burner (B) and has reduced the temperature to 130° F. in paragraph 4.7(c). In like vein, two commentators said the -40° F. proposed in paragraph 4.7(d) was too low and recommended it be set at +20°. We agree that in the event of decompression, it would be unrealistic for the cabin to remain at -40° F. long enough to enable equipment to cool to this temperature.

Objections were raised to the proposed paragraph 4.8 on the grounds that it did not indicate how compliance with paragraphs 4.1 through 4.6 would be determined, that the term "simulated flow conditions" was not clearly defined, and that it did not define the vibration to be applied. We do not agree that the vibration need be defined, for example, as sinusoidal with a logarithmic sweep rate, as one commentator suggested. However, we do agree that some clarification is necessary. Accordingly, paragraph 4.8 has been amended to require independent vibration and flow endurance tests of definite duration. The *tables* have been deleted and the requirements now stated in text form to make it clear that compliance with paragraphs 4.1 through 4.4 must be shown after the vibration and flow endurance tests. We agree further that mask-mounted regulator vibration requirements may be less strict than for panel-mounted regulators, and the mask-mounted regulators have been exempted *from* the vibration requirements. The reference to "demand regulators" in the first sentence of paragraphs 4.8 and 4.9 is sufficiently clear without listing all specific types in view of paragraph 2, *Classification*.

Paragraph 4.10 proposed compliance with paragraph 4.1 although its applicability extended only to subparagraph 4.1(a). The Agency agrees with the commentators who pointed out the inconsistency and paragraph 4.10 has been amended to clarify its applicability.

For the reasons discussed previously in connection with TSO-C78, Crewmember Demand Oxygen Masks, paragraph 5.0 has been reworded to refer to maximum environmental (cabin) altitude.

The Agency rejects the suggestion that "each lot" used in paragraph 6.2 be carefully defined. As discussed previously in connection with crewmembers mask TSO-C78, lot size in relation to quality control, is dependent on a number of variables so that it is not practical to define it in the TSO. The general requirements of a quality control system are stated in paragraphs 37.5 and 37.15 of the FARs and need not be repeated in the TSO itself. Neither does the Agency agree with a suggestion that would delete the requirement to requalify one regulator for each lot. Requalification provides a check of continued compliance with all the pertinent requirements and is considered essential.

Complying with several responses to the notice, paragraph 7 has been amended to correct the abbreviations and definitions relating to "STPD" and "g". "ATPD" has been added to the list.

One recommendation that separate standards be promulgated for mask-mounted and panel-mounted regulators has been effectively accomplished by including separate reference, when necessary, to mask-mounted regulators. The TSO, as revised, is therefore applicable to both. Other recommendations that the TSO incorporate installation and operational requirements must be rejected as beyond the general scope and intent of any TSO. A flat recommendation that the TSO requirement be equivalent to existing military requirements fails to recognize that civil requirements are often different from military requirements. Insofar as practicable, Agency standards utilize applicable portions of the military specifications.

One commentator made the general objection that the proposed TSO went beyond minimum requirements and, in fact, pushed the state-of-the-art. In considering the detailed comments from all sources, however, we have incorporated those recommendations which permitted a relaxation in the proposal. Furthermore, no comment pointed out any specific unreasonable requirement or any requirement believed impossible to meet. We consider, therefore, that the standards are appropriate minimum requirements and do not exceed the state-of-the-art.

Interested persons have been afforded the opportunity to participate in the making of this amendment and all relevant material submitted has been fully considered.

(Secs. 313(a), 601, Federal Aviation Act of 1958; 49 U.S.C. 1354, 1421)

In consideration of the foregoing, and pursuant to the authority delegated to me by the Administrator (25 F.R. 6489), Part 37 of the Federal Aviation Regulations is amended by adding new §§ 37.184 and 37.186, as hereinafter set forth, effective February 10, 1967.

Issued in Washington, D.C., on December 29, 1966.

C. W. WALKER,
Director, Flight Standards Service.

§ 37.184 Crewmember demand oxygen masks—TSO–C78.

(a) *Applicability.* This TSO prescribes the minimum performance standards that aircraft crewmember demand oxygen masks must meet in order to be identified with the applicable TSO marking. New models of demand oxygen masks that are to be so identified and that are manufactured on or after February 10, 1967, must meet the requirements of the following "Federal Aviation Agency Standard, Crewmember Demand Oxygen Masks."

(b) *Marking.* Each oxygen mask manufactured in accordance with the provisions of this section must be marked—

(1) To indicate whether it is a "nonpressure demand" or a "pressure demand" mask;

(2) To indicate the maximum environmental (cabin) altitude for which it is qualified; and

(3) As specified in § 37.7, except that the markings need not include the serial number, the weight, or the date of manufacture.

(c) *Data requirements.* In accordance with § 37.5, the manufacturer must furnish to the Chief, Engineering and Manufacturing Branch, Flight Standards Division, Federal Aviation Agency, in the region in which the manufacturer is located, the following technical data:

(1) Seven sets of manufacturer's operating instructions and equipment limitations.

(2) Seven sets of installation procedures with applicable drawings and specifications, limitations, restrictions, and other conditions pertinent to installation.

(3) One copy of the manufacturer's test report.

(4) One copy of the manufacturer's maintenance instructions, including cleaning and sterilizing procedures.

(d) *Previously approved equipment.* Crewmember demand oxygen masks approved prior to February 10, 1967, may continue to be manufactured under the provisions of the original approval.

FEDERAL AVIATION AGENCY STANDARD

CREWMEMBER DEMAND OXYGEN MASKS

1.0 *Purpose.* This Standard contains minimum performance standards for the manufacture of demand type oxygen masks for use with nonpressure demand (straight-demand and diluter-demand) and pressure-demand oxygen systems.

2.0 *Design and construction of mask.* To be eligible for approval under a Technical Standard Order authorization, the oxygen mask must possess the following design and construction characteristics.

2.1 Masks designed for use with a remotely located oxygen flow regulator must include a flexible oxygen supply tube fixed or detachable at the mask or at the regulator or at both. Oxygen supply tubes used in conjunction with mask-mounted oxygen flow regulators are not subject to this paragraph.

2.2 The mask must be designed for respiration through the nose and mouth (oronasal). The mask may also include integral goggles designed to protect the eyes from smoke and harmful gases (fullface).

2.3 The mask must be constructed of materials that—

(a) Do not contaminate air or oxygen;

(b) Are not adversely affected by continuous contact with oxygen; and

(c) Are at least flame resistant.

2.4 The mask must be designed to prevent the accumulation of hazardous quanti-

ties of expiratory gases within the facepiece chamber.

2.5 The mask must be designed to prevent the formation or accumulation of frost which would interfere with the function of the exhalation valve, unless it can be shown that the frost can be removed by external manipulation without removing the mask from the face of the user.

2.6 The fullface mask must be designed to include means for the prevention or the removal of condensation from the inside surfaces of the goggle lenses.

2.7 Masks equipped with oxygen supply tubes designed for quick disconnection at the mask or at the regulator must incorporate means to alert the user when his oxygen supply tube has become disconnected. Such means must not restrict the flow of ambient air through the oxygen supply tube by an amount exceeding 25 percent. This section does not apply if the quick disconnect device incorporates means to prevent inadvertent separation.

3.0 *Performance.* Five masks of each kind for which approval is sought must be shown to comply with the minimum performance standards set forth in paragraphs 3.1 through 3.12, except that only one mask of each kind is required to comply with the provisions of paragraphs 3.6, 3.8, 3.9, and 3.11. Tests must be conducted at ambient atmospheric conditions of approximately 30" hg and 70° F., except as otherwise specified. Gas flow rates and pressures must be corrected to STPD.

3.1 *Quick-disconnect coupling.* The force required to separate quick-disconnect couplings not designed to prevent inadvertent separation must not be less than 10 pounds exerted along the axis of symmetry of the oxygen supply tube.

3.2 *Strength.* (a) The mask must be capable of sustaining a pull force on the suspension device attachment fittings of not less than 35 pounds in any direction for a period of not less than 3 seconds.

(b) The oxygen supply tube assembly must be capable of sustaining a pull force of not less than 30 pounds exerted along the axis of symmetry of the tube for a period of not less than 3 seconds.

(c) The oxygen supply tube assembly must be capable of sustaining an internal pressure of 1.5 p.s.i.g.

3.3 *Leakage.* (a) The total inward leakage rate, with the complete mask positioned on the face or on a suitable test stand in a manner which simulates normal use, must not exceed 0.10 LPM, STPD, at any negative differential pressure within the range of from zero to 6.0 inches of water.

(b) Inhalation valves installed in pressure-demand masks must not backleak more than 0.015 LPM, STPD, when subjected to a suction pressure differential of 0.1" H_2O and not more than 0.15 LPM, STPD, when subjected to a suction pressure differential of 12.0" H_2O.

(c) The oxygen supply tube assembly must not leak when subjected to an internal pressure of 1.5 p.s.i.g.

3.4 *Flow resistance.* (a) The inspiratory resistance of the mask and oxygen supply tube including the oxygen supply connector when inserted in an appropriate mating fitting must not exceed the following negative differential pressures at the corresponding oxygen flow rates:

Differential pressure (inches H_2O)	*Flow rate* (*LPM*)
0.5	20
1.5	70
2.5	100

(b) The expiratory resistance of the mask must not exceed the following positive differential pressures at the corresponding oxygen flow rates:

Differential pressure (inches H_2O)	*Flow rate* (*LPM*)
1.0	20
2.0	70
3.0	100

3.5 *Pressure-demand exhalation valve performance.* The exhalation valve installed in a pressure-demand mask must open when the pressure within the facepiece is 20 mm. Hg. and the pressure in the supply tube is 15 to 19.9 mm. Hg.

3.6 *Vibration.* The flow of gases during the respiratory process must not cause vibration, flutter, or chatter which would interfere with the satisfactory operation of the mask.

3.7 *Acceleration load.* The exhalation valve must not inadvertently operate under a 3g. load applied in any direction.

3.8 *Extreme temperature.* The mask must comply with paragraphs 3.3 through 3.5 in an ambient temperature of 70° F. within 15 minutes after being stored at a temperature of 160° F. for 12 hours, and within 15 minutes after being stored at 0° F. for 2 hours. The relative humidity during storage must vary from 5 to 95 percent. The mask facepiece must not be gummy or sticky and must provide a normal seal after the high temperature exposure.

3.9 *Low temperature test delay.* (a) The mask must function properly, without apparent delay, at a temperature of 70° F. after being stored at a temperature of 20° F. for not less than 2 hours.

(b) The mask must function properly, without apparent delay, and continue for a period of not less than 15 minutes when tested at a temperature of 20° F. after being stored at a temperature of 70° F. for not less than 12 hours.

3.10 *Decompression.* (a) A mask not equipped with a pressure relief valve must not suffer damage and must comply with paragraphs 3.3 through 3.5 after being subjected to a decrease in ambient pressure from 13 p.s.i.a. to not less than 3.7 p.s.i.a. for a straight or diluter-demand kind, or to not less than 2.1 p.s.i.a. for a pressure-demand kind, within a period of not more than 1 second. This decompression test must simulate the condition that would be imposed on a mask being worn by a crewmember during the specified decompression.

(b) A mask equipped with a pressure relief valve must be subjected to the decompression specified in subparagraph (a) of this section during which the pressure relief valve must open at a differential pressure of 17" H_2O and must relieve the differential pressure to a value not exceeding 16" H_2O within 5 seconds. During the 5-second interval, the pressure differential must not exceed a value of 20" H_2O. The pressure relief valve must close at a differential pressure of 14" H_2O.

3.11 *Cycling.* The mask must comply with paragraphs 3.3 through 3.5 after being subjected to the following simulated breathing schedule for a total of 20,000 cycles:

Respiratory cycles	Minute flow rate LPM, STPD	Volume, tidal liters
10,000	20	1.0
8,000	50	1.5
2,000	70	2.0

A constant time interval must be maintained between respiratory cycles.

3.12 *Microphone.* If the mask is designed to include a microphone, the installation of the microphone must not interfere with the operation of the mask.

4.0 *Quality control*—4.1 *Production tests.* Each mask must be shown to comply with the provisions of paragraph 3.3(a), total leakage.

4.2 *Random tests.* One mask must be selected at random from each lot and must be shown to comply with paragraphs 3.1 through 3.12. The lot size must be selected by the applicant subject to the approval of the Federal Aviation Agency (see PAR § 37.5), on the basis of evaluation of the applicant's quality control systems (see § 37.5(a)(3)).

5.0 *Maximum environmental (cabin) altitude.* The minimum pressure to which the mask has been shown to decompress satisfactorily in accordance with paragraph 3.10 (a) or (b) of this standard determines the maximum environmental altitude of the mask, except that it shall not exceed the value shown in the following table:

Maximum environmental (cabin) altitude	*Kind of mask*
40,000 feet	Straight or Diluter-Demand.
45,000 feet	Pressure Demand.

6.0 *Abbreviations and definitions.*

LPM: Liters per minute.
STPD: Standard temperature and pressure, dry (0° C. 760 mm. Hg.).
p.s.i.g.: Pounds per square inch, gage.
p.s.i.a.: Pounds per square inch, absolute.
g.: Acceleration of gravity, 32.2 feet/second.²
Tidal volume: Volume of air inspired per breath.

§ 37.198 Oxygen regulators, demand—TSO-C89.

(a) *Applicability.* This technical standard order prescribes the minimum performance standards that aircraft demand oxygen regulators must meet in order to be identified with the applicable TSO marking. New models of demand oxygen regulators that are to be so identified and that are manufactured on or after February 10, 1967, must meet the requirements of the following "Federal Aviation Agency Standard, Oxygen Regulators, Demand."

(b) *Marking.* In addition to the markings required by § 37.7, the inlet supply pressure range and the maximum environmental (cabin) altitude must also be marked on the regulator.

(c) *Data requirements.* The manufacturer must furnish the Chief, Engineering and Manufacturing Branch, Flight Standards Division, Federal Aviation Agency, in the region in which the manufacturer is located, the following technical data:

(1) Seven copies of the manufacturer's operating instructions, equipment limitations, and installation procedures.

(2) One copy of the manufacturer's test report.

(d) *Previously approved equipment.* Oxygen regulators approved prior to February 10, 1967, may continue to be manufactured under the provisions of the original approval.

Federal Aviation Agency Standard

Oxygen Regulators, Demand

1. *Purpose.* This standard contains minimum performance and quality control standards for the manufacture of demand oxygen system regulators.

2. *Classification.* The term "demand regulator" includes all of the following classes of regulators:

(a) Straight demand regulators designed to deliver oxygen only.

(b) Diluter demand regulators designed to deliver a mixture of oxygen and air, and oxygen only.

(c) Straight demand pressure breathing regulators (straight demand regulators designed to deliver undiluted oxygen under positive pressure).

(d) Diluter demand pressure breathing regulators (diluter demand regulators designed to deliver undiluted oxygen under positive pressure).

3. *Design and construction of regulator.* To be eligible for approval under a TSO authorization, the regulator must possess the following design and construction characteristics:

3.1 Demand regulators designed to be mounted directly upon an oxygen mask or the crewmember's clothing or safety harness must include a flexible oxygen supply tube connecting the regulator inlet with the oxygen supply system.

3.2 Demand regulators must be constructed of materials that—

(a) Do not contaminate air or oxygen;

(b) Are not adversely affected by continuous contact with oxygen; and

(c) Are at least flame resistant.

equipped with a 100-mesh screen, or equivalent filter, at the oxygen inlet port or at the oxygen inlet hose assembly.

(b) Diluter demand and diluter-demand pressure regulators must be equipped with screening of not more than 100 mesh and not less than 30 mesh, or equivalent filter, at the air inlet port.

3.4 Diluter demand and diluter-demand pressure breathing regulators must be provided with a means for manually selecting a delivery of undiluted oxygen. If the selection means is controlled by a rotating handle or lever, the travel must be limited to not more than 180 degrees from the "normal oxygen" position to the "100 percent oxygen" position. The dilution position of the selection means must be designated "normal oxygen" and the nondilution position must be designated "100 percent oxygen." The selection means must be such that it will not assume a position between the "normal oxygen" and "100 percent oxygen" positions.

3.5 Straight demand pressure breathing and diluter demand pressure breathing regulators must be designed to provide oxygen at a positive pressure of 11.0±3.0 inches H_2O to determine mask peripheral leakage at altitudes below which positive pressure are hereinafter required. The means of obtaining this pressure must be by push, pull, or toggle control appropriately marked to indicate its purpose.

3.6 Diluter demand and diluter demand pressure breathing regulators must incorporate means to indicate when oxygen is and is not flowing from the regulator outlet. This requirement does not apply to mask mounted regulators.

4. *Performance.* Two demand regulators of each class for which approval is sought must be shown to comply with the minimum performance standards set forth in paragraphs 4.1 through 4.10 in any position which the regulators can be mounted. Tests must be conducted at ambient atmospheric conditions of approximately 30 inches Hg and 70° F., except as otherwise specified. It is permissible to correct gas flow rates and pressures to STPD conditions by computation.

4.1 (a) Demand regulators must supply the following oxygen or oxygen-air flows at not more than the specified outlet pressures. These characteristics must be displayed at all altitudes, with the oxygen supply pressure at all values within the design inlet pressure range, and with the diluter valve open and closed.

Flow, LPM, ATPD:	*Maximum outlet suction pressure, inches of water*
20	0.40
70	.80
100	1.00

(b) Demand regulators must not flow more than 0.01 LPM, STPD, when the outlet suction pressure is reduced to 0 inch of H_2O under the conditions specified in subparagraph (a) of this paragraph.

4.2 (a) Diluter demand and diluter demand pressure breathing regulators must supply the following percentages of cylinder oxygen, by volume, at the specified atmospheric pressures and corresponding altitudes. These oxygen percentages must be delivered at regulator outlet gas flows of 20, 70, and 100 LPM, ATPD, with the oxygen supply pressure at all values within the design inlet pressure range.

Pressure mm Hg	Altitude feet	Minimum percent oxygen	
		Diluter demand	Diluter demand pressure breathing
760	[illegible]	0	40
682.4	[illegible]	0	40
522.6	[illegible]	0	40
429.1	[illegible]	14	40
380.9	[illegible]	33	40
282.4	[illegible]	40	40
226.1	[illegible]	40	40
179.3	[illegible]	40	40
178.5	[illegible]	40	40
141.2	[illegible]	40	40
111.1	[illegible]	(1)	40

(1) Not applicable

(b) Straight demand and straight demand pressure breathing regulators must supply not less than 98 percent oxygen, by volume, at all altitudes under the conditions specified in subparagraph (a) of this paragraph.

4.3 (a) Diluter demand pressure breathing regulators with the diluter valve open or closed, and straight demand pressure breathing regulators, must provide positive breathing pressure at a flow of 20 LPM, ATPD, in accordance with the following table:

Altitude 1,000 feet	*Positive outlet pressure—H_2O*
30	0.0+3.5 −0.0
40	2.5±2.5
42	6.0±1.5
44	10.0±1.0
45	12.0±1.0

(b) The positive pressure at 100 LPM, ATPD, must not decrease by more than 0.8 inch H_2O from the positive pressure at 20 LPM, ATPD.

(c) The positive pressure at 0.01 LPM, ATPD, must not increase by more than 0.8 inch H_2O from the positive pressure at 20 LPM, ATPD.

4.4 (a) The inward leakage of air through the regulator at sea level must not exceed 0.1 LPM, STPD, with a suction pressure of 1.0 inch H_2O applied to the outlet port, the oxygen supply inlet port sealed, and the diluter valve closed.

(b) The outward leakage of air through the regulator at sea level must not exceed 0.1 LPM, STPD, with a positive pressure of 12 inches H_2O applied to the outlet port, the oxygen supply inlet port sealed, and the diluter valve open and closed.

(c) The regulator outlet leakage must not exceed 0.01 LPM, STPD, with the regulator outlet port open and any oxygen supply pressure within the specified operating range applied at the regulator inlet port.

(d) The regulator overall leakage must not exceed 0.01 LPM, STPD, with the regulator outlet port sealed and the regulator inlet port pressurized to a value equal to the maximum specified oxygen supply pressure.

4.5 (a) Straight demand pressure breathing and diluter demand pressure breathing regulators must comply with paragraphs 4.1 through 4.4 after a negative pressure of 20 inches H_2O and a positive pressure of 24 inches H_2O are applied to the outlet port for a period of 2 minutes. The diluter valve and the regulator inlet port must be closed during these two pressure tests.

(b) Straight demand and diluter demand regulators must comply with paragraphs 4.1 through 4.4 after a negative pressure of 20 inches H_2O and a positive pressure of 12 inches H_2O are applied to the outlet port for a period of 2 minutes. The diluter valve and the regulator inlet port must be closed during these two pressure tests.

(c) Demand regulators must comply with paragraphs 4.1 through 4.4 after a positive pressure of 1.5 times the maximum oxygen supply pressure is applied to the inlet port, or to the inlet of the oxygen supply tube in the case of mask mounted regulators, for a period of 2 minutes. The positive pressure must be applied rapidly to simulate rapid valve [illegible] and the outlet port inlet be sealed during the test.

4.6 (a) Straight demand and diluter demand regulators must comply with paragraphs 4.1 through 4.4 after being subjected to a change in pressure from not less than 13.2 p.s.i.a. to not less than 2.7 p.s.i.a. in not more than 1 second.

(b) Straight demand pressure breathing and diluter demand pressure breathing regulators must comply with paragraphs 4.1 through 4.4 after being subjected to a change in pressure from not less than 13.2 p.s.i.a. to not less than 2.1 p.s.i.a. in not more than 1 second.

4.7 Demand regulators must comply with paragraphs 4.1 through 4.4 under each condition specified in subparagraphs (a) through (d) of this paragraph with the maximum oxygen supply pressure applied to the regulator inlet:

(a) At a temperature of approximately 70° F. after being stored at a temperature of not less than 160° F. for 12 hours.

(b) At a temperature of 70° F. after being stored at a temperature of not warmer than −67° F. for 2 hours.

(c) At a temperature of not less than 130° F.

(d) At a temperature of not more than 20° F.

4.8 Demand regulators must comply with paragraphs 4.1 through 4.4 after being subjected to the tests specified in subparagraphs (a) and (b) of this paragraph.

(a) The regulator must be vibrated along each mutually perpendicular axis for 1 hour (3 hours total), at a frequency of 5 to 500 cps, and at a double amplitude of 0.036 inches or an acceleration of 2 "g," whichever occurs first. Mask mounted regulators need not be subjected to this vibration test.

(b) The regulator must be subjected to an endurance test of a total of 250,000 breathing cycles. The peak breathing rate must be 90 LPM, STPD, for 200,000 cycles, and 70 LPM, STPD, for 50,000 cycles. The dilution valve must be open during one half of the 200,000 cycles and one half of the 50,000 cycles, and it must be closed during the remaining cycles. During the nonflow portion of the 90 LPM and 70 LPM breathing cycles, a back pressure of 0.5 and 1.0 inches H_2O, respectively, must be applied to the regulator outlet.

4.9 Demand regulators must be free of vibration, flutter, or chatter that will prevent compliance with paragraphs 4.1 through 4.3 when subjected to the following simulated flow conditions:

Cycles	Peak flow per cycle LPM, STPD	Back pressure at 0 LPM, inches H_2O	Diluter valve
4,000	160	1.8	Closed.
4,000	160	1.8	Open.

4.10 Demand regulators, when subject to accelerations up to 8 "g." in any position, must comply with paragraph 4.1(a) except that the specified suction pressures may be exceeded by not more than 0.8 inches H_2O.

5. *Maximum environmental (cabin) altitude.* The minimum pressure to which the regulator has been shown to comply under paragraph 4.6 (a) or (b) of this standard determines the maximum environmental (cabin) altitude of the regulator, except that the maximum environmental (cabin) altitude must not exceed the value shown in the following table:

Class	Feet
Straight or diluter-demand	40,000
Pressure demand	45,000

6. Quality control. 6.1 Each production regulator must be shown to comply with paragraphs 4.1 through 4.4.

6.2 One regulator selected at random from each lot must be shown to comply with paragraphs 4.1 through 4.10. The lot size may be selected by the applicant subject to the approval of the Federal Aviation Agency on the basis of evaluation of the quality control system of the applicant (see FAR, § 37.5).

7. Abbreviations and definitions.

LPM: Liters per minute.

STPD: Standard temperature and pressure, dry (0° C., 760 mm. Hg., $PH_2O=0$).

ATPD: Ambient temperature and pressure, dry (70° F.; ambient pressure; $PH_2O=0$).

c.p.s.: Cycles per second.

p.s.i.a.: Pounds per square inch absolute.

g.: Acceleration of gravity, 32 feet/second/second.